

COMPARISON OF TRADITIONAL AND INDUSTRIAL MULTILAYERED PLASTERS AGAINST THE SALT CRYSTALLIZATION ACTION

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Abstract

This paper intends to improve the knowledge on rendering mortars for ancient buildings, by comparing traditional and industrial multilayered plasters in terms of their resistance to the damaging action of salt crystallization. To carry out this study, seven mortars were studied: three undercoat mortars and four topcoat mortars. The seven mortars were combined in order to obtain four two-coat systems (two made of industrial mortars and another two made of traditional mortars), which were applied on masonry specimens. The undercoat mortars were also applied as one-coat systems to understand the influence of the topcoat. Physical and mechanical characterization was performed on prismatic specimens made from these mortars. Additionally, tests of absorption by capillarity, drying behavior and water vapor permeability were performed on plaster specimens collected from the masonry supports, in order to assess the single and combined behavior of the mortars. A salt crystallization test was carried out on masonry specimens and the effects of salt degradation on them were studied. It was concluded that the traditional plasters presented durability problems, related to disintegration, due to a poor mechanical resistance. Regarding the industrial plasters, they showed detachment of the whole plaster, which is caused by the lower permeability to water and greater mechanical resistance than the masonry support. It was also concluded that, in terms of durability, the two-coat systems presented better results than the one-coat systems.

Keywords: *Industrial plasters; traditional plasters; two-coat plasters; salt crystallization; mortars' characterization.*

1 INTRODUCTION

The development of old buildings rehabilitation market, coupled with the limitations of lime-based mortars, has motivated the industry to produce specific pre-dosed mortars for plastering in this type of buildings. In an intervention scenario on the plaster of an old building, the adoption of mortars similar to the original ones corresponds to the solution that guarantees compatibility with the support.

This paper intends to give a contribution in this domain, improving the knowledge of the behavior of industrial mortars comparing to the traditional ones, that are usually found in old buildings. In addition to the several physical and mechanical characteristics that have been studied, this article focuses on the problem of the crystallization of soluble salts in the plasters, one of the main degradation factors (1; 2).

In the case of old constructions, the supports are usually constituted by structural masonry and it is therefore a priority to protect these elements. In addition to the protection function, the plasters still have a decorative function and, therefore, should be designed to maximize their durability (3). These plasters must have sufficient mechanical strength to ensure the cohesion of their constituents and adhesion thereof to the support. However, they must have less mechanical strength than the support and sufficient deformability to accompany the deformations (3; 4). Regarding the presence of water, the plaster must have a good resistance to water penetration and a good drying capacity, and the evaporation of the water must occur under conditions that minimize the aggressive action of the soluble salts. By fulfilling these requirements, there are guarantees of adequate plaster durability (5; 2).

The main aim of this study is to compare industrial and traditional plasters against the salt damaging action. Since ancient plasters are usually composed of many layers of different mortars, the influence of the topcoat on

the salt resistance was also addressed. Finally, the study also examined the influence of the porosity characteristics of the mortars in the degradation and durability of the plasters exposed to the salt action.

To achieve these aims, seven mortars were studied: three undercoat mortars and four topcoat mortars. The seven mortars were combined in order to obtain four two-coat systems (two made of industrial mortars and another two made of traditional mortars), which were applied on masonry specimens. The undercoat mortars were also applied as one-coat systems to understand the influence of the topcoat. Among each type (undercoat, topcoat, industrial, traditional) mortars showing diverse porosity characteristics were selected.

Mortars were first characterized in terms of their main physical and mechanical properties evaluated in $4 \times 4 \times 16$ cm prismatic specimens (flexural and compressive strength, dynamic modulus of elasticity, ultrasonic-pulse velocity, water immersion under vacuum and water absorption by capillarity). Then, the mortars were applied as plasters on a small prototype masonry wall and their water vapor permeability and drying behavior was determined on plaster specimens collected from the masonry prototype. Finally, a salt crystallization test was conducted on the plasters. The comparative behavior between the diverse plasters in relation to the salt damaging action was analyzed and related to the water transport and mechanical properties previously assessed.

2 MATERIALS AND METHODS

2.1 Mortars and masonry prototypes

Three pre-dosed mortars supplied from Weber were produced: one undercoat mortar and one topcoat mortar. These mortars, from now on, will be simply designated as R1, R2 and A1, respectively.

The mortar R1, based on hydrated aerial lime (major binder), pozzolanic binders, cement, limestone and silicium aggregates, light aggregates, synthetic fibers, water repellent agents and workability regulating agents (cellulose) was preformed using 1130,86 g of weber.cal.classic mixture and 192,25 g of water (0,17 ratio).

The mortar R2, based on hydrated aerial lime (major binder), pozzolanic binders, cement, limestone and silicium aggregates, light aggregates, synthetic fibers, air introducing agents, water repellent agents, and workability regulating agents (cellulose) was preformed using 1105,85 g of weber.cal.sane mixture and 210,11 g of water (0,19 ratio).

The mortar A1, based on hydrated aerial lime (major binder), cement, limestone aggregates, light aggregates, synthetic fibers, water repellent agents, and workability regulating agents (cellulose) was preformed using 1026,39 g of weber.cal.decor mixture and 266,86 g of water (0,26 ratio).

The amount of water used in the mixtures was selected so that a 160 ± 5 mm flow in the table flow test (EN 1015-3:1999) could be achieved and considering the range values suggested by the supplier. The mortars were prepared following the procedures recommended in EN 196-1:2005 and the experience of previews works (6; 7).

Four traditional mortars, originated from previous studies, were also studied (8). These are CL90 lime-based mortars, with a binder to aggregate proportion of 1:3 and 1:1, for undercoat and basecoat mortars, respectively. There were two undercoat mortars, designated as USL1 and USL2, whose water-binder ratio was of 1,6 and 1,2, respectively. The other two were topcoat mortars, designated as TSL1 and TSL3, with a water-binder ratio was of 1,0 and 0,85, respectively. These mortars were produced and applied in a masonry prototype, using the following combinations: two one-coat systems (ULS1 and USL6) and two two-coat systems (USL1+TSL1 and USL6+TSL3).

The masonry prototype was a small piece of wall with about $30 \times 30 \times 10$ cm³ made of natural limestone blocks and lime mortar (Figure 2). Specimens from the pre-existing traditional plasters were carefully extracted

in small specimens with $4 \times 4 \times 2 \text{ cm}^3$ and $4 \times 8 \times 2 \text{ cm}^3$. The surface of the masonry prototype left available by the extraction of the small prototypes was covered by the industrial plasters, in the following scheme: two one-coat systems (R1 and R2) and two two-coat systems (R1+A2 and R1+A1). After the curing and hardening of the industrial plasters, specimens similar to those previously described for traditional plasters were extracted from the masonry prototype.

2.2 Mortars and plasters characterization

The characterization of mortars involved mechanical and physical tests performed in prisms and plasters. The characterization in prisms comprised the determination of porosity and bulk density, compressive and flexural strength, ultrasonic pulse velocity, dynamic modulus of elasticity, water capillary absorption and carbonation depth. The determination of porosity and bulk density, water capillary absorption, water vapor permeability and drying behavior was also carried out in the plaster prototypes. The prisms and the plaster prototypes were kept in a controlled chamber with $20 \pm 2^\circ\text{C}$ and $60 \pm 5\% \text{ RH}$ until testing. Both prisms and renders were tested after, at least, 90 days. The prisms and plasters to be used in water absorption tests were dried in an oven at $60 \pm 5^\circ\text{C}$ for 72 hours.

Compressive and flexural strength tests were based on EN 1015-11:1999 and carried out using a Form test-Sneider universal machine, model D-7940. The ultrasonic pulse velocity was measured by means of a PUNDIT Lab equipment from Proceq and two cylindrical transducers of 5 cm diameter with a frequency of 54 kHz. The dynamic modulus of elasticity was assessed by the resonant frequency method, in accordance with ASTM E 1876-01, using a Grindosonic E-modulus measurement equipment. Porosity and bulk density were based on EN 1015-6 (1998.)

The water absorption by capillarity was determined based on EN 1015-18:2002.

The water vapor permeability was assessed by means of a set-up based on the RILEM II.2 and on protocols previously developed in other works (8) for the same purpose. The operating principle lies in measuring the increasing weight of small cups where specimens are placed – the measuring cells. A water vapor flux arises between the humid external environment ($\text{RH} \cong 75\%$) and the dryer air existing inside the cell ($\text{RH} \cong 10\%$), causing its weight increase. Stable temperature conditions of $T \cong 25^\circ\text{C}$ were ensured. The specimens are the $4 \times 4 \times 2 \text{ cm}^3$ plaster specimens, horizontally placed inside a hole existing in the cover of the cells. The lateral faces of the specimens ($4 \times 2 \text{ cm}$) were sealed with an epoxy resin (Sikadur® - 32N, Sika) to ensure unidirectional water vapor flux.

The drying tests were based on RILEM II.5. The specimens are $4 \times 8 \times 2 \text{ cm}^3$ plaster specimens. The saturated specimens were placed to dry with the lateral and bottom faces sealed and the top face exposed to evaporation. The environmental conditions were ($T = 20 \pm 2^\circ\text{C}$ and $\text{RH} = 60 \pm 5\%$).

2.3 Crystallization test

The crystallization test was adapted from the procedure adopted by Nogueira (8). This procedure is constituted by four steps, in which each step comprehends 3 crystallization/dissolution stages.

The first stage (A) aims to contaminate the plaster with a sodium chloride solution (15% w/w), while, simultaneously, comprises a wetting/drying cycle. As for stages B.1 and B.2, their aim is to wet the masonry prototypes and the plasters, with distilled water, allowing the dissolution of the salt introduced in stage A, comprising wetting/drying cycles. Each step includes the repetition of these 3 stages.

The wetting is achieved by the water capillary rise and was considered completed after 2 hours with the specimen saturation. For the drying, the masonry prototypes were placed in an oven, at $40 \pm 5^\circ\text{C}$, for 7 days. Then, at the end of the stage, a visual examination was conducted (as well as to the touch), to identify the formation of efflorescence and superficial or deep degradation of the plasters.

3 RESULTS AND DISCUSSION

3.1 Characterization in prisms

3.1.1 Physical properties

The main results concerning the physical properties of mortars are presented in Table 1.

Table 1: Physical properties

| Mortar | $\rho^1(\text{kg.m}^{-3})$ | $\rho_b^2(\text{kg.m}^{-3})$ | $P_w^3(\%)$ |
|--------|----------------------------|------------------------------|----------------|
| USL1 | 2620 ± 10 | 1910 ± 8 | $26,8 \pm 0,3$ |
| USL6 | 2620 ± 7 | 1990 ± 9 | $23,8 \pm 0,4$ |
| TSL1 | 2610 ± 8 | 1710 ± 11 | $34,5 \pm 0,4$ |
| TSL3 | 2600 ± 19 | 1760 ± 8 | $32,1 \pm 0,3$ |
| R1 | 2360 ± 6 | 1623 ± 4 | $31,2 \pm 0,2$ |
| R2 | 2160 ± 11 | 1513 ± 2 | $29,9 \pm 0,4$ |
| A1 | 2303 ± 9 | 1362 ± 8 | $40,9 \pm 0,2$ |

¹real density; ²bulk density; ³porosity.

Results show that the undercoat mortars (USL1, USL6, R1 and R2) have lower porosity than the topcoat mortars (TSL1, TSL3 and A1). In the case of traditional mortars, this result is due to the greater aggregate bulk density (motivated by a wider grading curve of the sand) and to the smaller quantity of paste existing in undercoat mortars (8). As far as industrial mortars are concerned, it is only known that the mortar mixture fractions are not continuous, and, in the case of topcoat mortar, A1, the aggregates are very fine. Thus, it is expected that the greater porosity of mortar A1 than mortar R1 and R2, is partly explained by the same reasons presented for traditional mortars. Comparing traditional and industrial mortars, the results show that the latter are significantly more porous and less dense, in particular the topcoat mortar A1. Considering that the hydraulic binders used in the industrial mortars lead to denser pastes, these results should be explained by the adoption of air entraining admixtures often used in pre-dosed mortars aiming at reducing the mortars permeability. These admixtures induce a porosity based on large closed pores, which reduces the capillarity suction and, consequently, the permeability.

3.1.2 Mechanical properties

Results of mechanical properties obtained in prisms are shown in Table 2.

Table 2: Mechanical properties

| Mortar | $f_c^1(\text{MPa})$ | $f_t^2(\text{MPa})$ | $UPV^3(\text{m.s}^{-1})$ | $E_d^4(\text{GPa})$ |
|--------|---------------------|---------------------|--------------------------|---------------------|
| USL1 | $0,9 \pm 0,1$ | $0,33 \pm 0,04$ | 1530 ± 30 | $3,4 \pm 0,2$ |
| USL6 | $2,1 \pm 0,1$ | $0,49 \pm 0,06$ | 1870 ± 40 | $4,4 \pm 0,2$ |
| TSL1 | $2,4 \pm 0,2$ | $0,85 \pm 0,11$ | 1780 ± 70 | $4,3 \pm 0,1$ |
| TSL3 | $3,4 \pm 0,1$ | $0,89 \pm 0,12$ | 1920 ± 70 | $4,8 \pm 0,4$ |
| R1 | $10,1 \pm 0,3$ | $2,92 \pm 0,23$ | 2586 ± 13 | $8,8 \pm 0,1$ |
| R2 | $12,0 \pm 0,5$ | $3,04 \pm 0,14$ | 2650 ± 25 | $8,6 \pm 0,2$ |
| A1 | $4,7 \pm 0,1$ | $1,84 \pm 0,09$ | 1985 ± 13 | $3,9 \pm 0,1$ |

¹compressive strength; ²flexural strength; ³ultrasonic pulse velocity; ⁴dynamic modulus of elasticity (mean and standard deviation).

Despite the lower porosity, the compressive strength of traditional mortars is lower than that of industrial mortars, which is also verified in the tensile strength test. These data are corroborated by the results of the ultrasonic velocity test. Apart from mortar A1, the results of modulus of elasticity are also higher in industrial mortars. These results were expected, due to the stronger binders used in the industrial mortars, that offset the

above mentioned higher porosity. The mortar R2 has only hydraulic binders, whereas the mortars R1 and A1 take aerial and hydraulic binders; thus, the lower resistance of the latter was expected. The greater resistance of the mortar R2 in relation to the R1 is only visible in the compressive strength, since the values of flexural strength, ultrasonic velocity and dynamic modulus of these mortars are similar.

In the case of traditional mortars, undercoat mortars have generally less mechanical resistance (either compression as tension) than topcoat mortars. This result is explained by the higher amount of binder of the latter. Within each class of traditional mortars (undercoat and topcoat), it is possible to see that as the water binder ratio is reduced, there is an increase in mechanical strength, ultrasonic velocity and, finally, in the modulus of elasticity.

3.1.3 Water transport properties

The water transport behavior in prisms was assessed by means of water capillary absorption and the results are presented in Table 3.

Table 3: Water transport properties in prisms

| Mortar | W_{AC}^1 (kg.m ⁻² s ^{-0,5}) | W_{24h}^2 (kg.m ⁻²) | W_A^3 (kg.m ⁻²) |
|--------|--|-----------------------------------|-------------------------------|
| USL1 | 0,23 ± 0,02 | 7,1 ± 0,2 | 33,2 ± 0,9 |
| USL6 | 0,19 ± 0,01 | 2,5 ± 0,1 | 30,4 ± 0,1 |
| TSL1 | 0,36 ± 0,02 | 10,5 ± 0,4 | 50,2 ± 0,7 |
| TSL3 | 0,27 ± 0,00 | ≈ W_A | 45,8 ± 0,8 |
| R1 | 0,05 ± 0,00 | ≈ W_A | 31,16 ± 0,24 |
| R2 | 0,02 ± 0,00 | ≈ W_A | 9,30 ± 0,32 |
| A1 | 0,07 ± 0,00 | ≈ W_A | 44,93 ± 1,04 |

¹water absorption coefficient through capillarity; ²water absorption through capillarity after 24 hours; ³asymptotic water absorption through capillarity (mean and standard deviation).

There was a distinct behavior between traditional mortars and industrial mortars. Table 3 shows that the value of the capillary absorption coefficient of the traditional mortars is about 6 times higher than the values verified for the industrial mortars, proving that industrial mortars are substantially less permeable than traditional solutions.

3.2 Characterization of plasters

3.2.1 Physical properties

The main results concerning the physical properties of mortars assessed in plaster specimens are presented in Table 4.

Table 4: Physical properties of plaster specimens

| Mortar | ρ^1 (kg.m ⁻³) | ρ_b^2 (kg.m ⁻³) | P_w^3 (%) |
|-------------|--------------------------------|----------------------------------|-------------|
| USL1 | 2605 ± 5 | 1973 ± 10 | 24,3 ± 0,3 |
| USL1 + TSL1 | 2612 ± 2 | 1932 ± 2 | 26,0 ± 0,0 |
| USL6 | 2612 ± 2 | 2088 ± 2 | 20,1 ± 0,0 |
| USL6 + TSL3 | 2609 ± 0 | 1980 ± 9 | 24,1 ± 0,3 |
| R1 | 2435 ± 4 | 1643 ± 4 | 32,5 ± 0,1 |
| R1 + A1 | 2606 ± 9 | 1640 ± 13 | 31,8 ± 0,3 |
| R2 | 2266 ± 0 | 1526 ± 3 | 32,7 ± 0,2 |
| R2 + A1 | 2273 ± 1 | 1517 ± 4 | 33,3 ± 0,1 |

¹real density; ²bulk density; ³porosity (mean and standard deviation).

Except for R1 and R2 mortar, all the undercoat mortars show lower porosity, when applied to the masonry bases than when applied in prisms. However, the increasing order of porosity remains unchanged, except for mortar R1 and, consequently, R1+A1. Concerning to the density, all the mortars applied in the masonry prototypes present higher values than those presented by the mortars used in prisms. It follows that a higher degree of compaction is obtained in the manual application followed by manual tightening, compared to the compaction table used in the production of the prisms.

3.2.2 Water transport properties

The water transport behavior was assessed by means of water capillary absorption, drying and water vapor permeability tests. The results are presented in Table 5.

Table 5: Water transport properties

| Mortar | D_v^1 ($\times 10^{-10}$ kg.m ⁻¹ s ⁻¹ Pa ⁻¹) | μ^2 | IS ³ | W_{CA}^4 (kg.m ⁻² s ^{-0.5}) | W_{24H}^5 (kg m ⁻²) | W_A^6 (kg m ⁻²) |
|-------------|---|------------|-----------------|--|-----------------------------------|-------------------------------|
| USL1 | 0,175 ± 0,023 | 11,0 ± 1,5 | 3,5 ± 0,5 | 0,31 ± 0,04 | - | 2,68 ± 0,19 |
| USL1 + TSL1 | 0,158 ± 0,009 | 12,0 ± 0,6 | 6,0 ± 0,4 | 0,50 ± 0,01 | - | 4,12 ± 0,16 |
| USL6 | 0,134 ± 0,009 | 14,2 ± 1,0 | 3,5 ± 0,5 | 0,29 ± 0,01 | - | 2,44 ± 0,08 |
| USL6 + TSL3 | 0,136 ± 0,002 | 13,9 ± 0,2 | 6,7 ± 0,0 | 0,28 ± 0,01 | - | 4,30 ± 0,29 |
| R1 | 0,108 ± 0,006 | 17,7 ± 0,9 | 13,1 ± 0,6 | - | 1,89 ± 0,10 | 2,34 ± 0,26 |
| R1 + A1 | 0,113 ± 0,004 | 16,8 ± 0,6 | 26,2 ± 0,2 | - | 2,29 ± 0,16 | 3,60 ± 0,10 |
| R2 | 0,087 ± 0,003 | 22,0 ± 0,8 | 41,2 ± 1,0 | - | 0,88 ± 0,16 | 1,82 ± 0,31 |
| R2 + A1 | 0,087 ± 0,003 | 21,8 ± 0,6 | 32,6 ± 1,2 | - | 1,35 ± 0,30 | 4,01 ± 0,84 |

¹Water vapor permeability; ²water vapor diffusion resistance coefficient; ³drying rate; ⁴water absorption coefficient through capillarity; ⁵water absorption through capillarity after 24 hours; ⁶Assymptotic water absorption through capillarity (mean and standard deviation).

Comparing industrial and traditional mortars, it can be seen that the formers are less permeable to water vapor, results consistent with those previously presented. The hydraulic binders plus the porosity characteristics based on large pores of industrial mortars should be the factors responsible for reducing the permeability to water, both in the liquid state and in the vapor state. Regarding the specimens removed from the two-coat plasters, their permeability of should be conditioned by the permeability of the less permeable layer (9), which is affected by the individual permeability characteristics of each layer. Table 5 shows the behavior described, except for the plasters USL1 and USL1 + TSL1. However, the high variability in permeability measurements suggests that there may have been other factors, such as some cracking, to raise the permeability value of the USL1 plaster.

For traditional mortars, drying is easier on regularization mortars (USL1 and USL6) and is becoming more difficult, following the order USL1 + TSL1 and USL6 + TSL3. Comparing the two-layer renders with the simple ones, it is verified that the existence of the finishing layer makes it difficult to dry the plaster, even though the finishing mortar is more permeable than the regularization mortar (Table 5).

For industrial mortars, drying becomes more difficult, following the order of R1, R1 + A1, R2 + A1 and R2. The foregoing reasoning may apply to renders R1 and R1 + A1 but not R2 and R2 + A1. It was found that the plaster made by the mortar R2 alone was the one that absorbed less water and the one that maintained more water at the end of the test (along with the double plaster R2 + A1). This behavior, due to the characteristics of the composition of the mortar R2, particularly, the presence of water repellent adjuvants, strongly penalizes the drying index. The same is no longer the case with double coat R2 + A1, due to an improvement of the drying characteristics imparted by the finishing layer.

Concerning to absorption through capillarity, industrial mortars show significantly lower coefficient of capillarity than traditional mortars, for the reasons previously advanced. It should be noted that the results obtained for the asymptotic value, shown in Table 5, are not comparable to each other since the specimens have different thicknesses. Comparing the results of the single and double plasters, the presence of a finishing layer in the USL1 + TSL1 plaster contributes to a significant increase in the capillary absorption coefficient. This

behavior is due to the high capillary absorption coefficient of the mortar TSL1 (8), which promotes the conduction of liquid water from the regularization layer. As already mentioned, finishing mortars have a higher capillary suction coefficient than regularization for two reasons: due to their greater porosity that promotes permeability and due to the smaller size of their pores that promotes capillary suction. However, the influence of the finish layer was only felt in the USL1 + TSL1 plaster. In the remaining samples (USL6+TSL3, R1+A1 and R2+A1), the influence of the finishing layer was not observed, probably due to the lower absorption characteristics of the mortars involved.

3.3 Crystallization Test

The results of the crystallization test are described in Table 6.

Table 6: Crystallization test

| Plaster | Visual Aspect | Description |
|---------------------------|---|--|
| Single Layer USL1 |  | Detachment of the plaster in the E4-A stage. The rupture surface occurred in the first layer (regularization mortar), about 1-2 mm from the interface with the support. |
| Double Layer USL1+TSL1 |  | At the end of the test (phase E4-B2) the finishing layer showed intense material disintegration. The plaster appeared to have good adhesion to the support. |
| Single Layer USL6 |  | Detachment of about 30% of the plaster area in the E4-A phase. The rupture surface occurred in the first layer of the plaster, about 1-2 mm from the interface with the support, similar to what occurred with the monolayer plaster USL1 |
| Double Layer USL6+TSL3 |  | Complete detachment of plaster in stage E3-B1. The rupture occurred by the interface between the regularization plaster and the support. |
| Single Layer R1 |  | Complete detachment of plaster in stage E3-B1. The surface of the plaster was with localized losses of material (in small amounts). Adhesive breakage between the plaster mortar and the stone elements of the support and cohesive between the plaster and the mortar of the joints between the stone elements of the masonry base. |

| | | |
|-------------------------------|---|---|
| <p>Double Layer R1+A1</p> |  | <p>At the end of the test (phase E4-B2) the finishing layer had localized material disaggregation. The plaster appeared to have good adhesion to the support.</p> |
| <p>Single Layer R2</p> |  | <p>Complete detachment of plaster in E4-A phase. The surface of the plaster did not exhibit any presence of crystallized salts. Adhesive breakage between the plaster mortar and the stone elements of the support and cohesive between the plaster and the mortar of the joints between the stone elements of the masonry base.</p> |
| <p>Double Layer R2+A1</p> |  | <p>Complete detachment of plaster in E4-A phase. The surface of the plaster with localized losses of material (in small quantities). Adhesive breakage between the plaster mortar and the stone elements of the support and cohesive between the plaster and the mortar of the joints between the stone elements of the masonry base.</p> |

This test shows that the finishing layer present in the double coatings has a beneficial effect on the durability of the same, compared to the single counter coat. The finishing layer is primarily responsible for a slower drying of the plaster. This phenomenon occurs in two phases, corresponding to the drying of the finishing layer and the under coat layer. Thus, when the plaster is saturated, the drying band lies on the surface causing efflorescence. Later, it retreats into the regularization layer, due to the high permeability of the finishing layer. After this point, the finishing layer reduces the partial pressure gradient of water vapor, causing the water flow gradient to be smaller compared to the simple plasters made with the same regularization mortar, where there is no finishing layer.

In the case of double plasters, the salts crystallize, in a first phase, on the surface in the form of efflorescence's and, in a second phase, the crystallization occurs slowly and gradually over the entire thickness of the regularization layer, thus allowing the distribution of the stresses introduced into the pores by the growth of the salt crystals.

About simple plasters, the drying front moves more quickly to the interface between the plaster and the masonry support, leading to a more expressive accumulation of salts in that area. Thus, this effect causes the detachment of the plaster and a potential damage of the support. The double layer plasters have a bigger potential to surface degradation at the level of the finishing layer by the action of the crystallization of salts than the simple plasters. However, the double plasters present better results from the point of view of structural integrity. Thus, it is concluded that the finishing layer acts as a sacrificial layer, protecting the regularization one and the support.

Comparing the performance of traditional and industrial plasters against structural and superficial integrity, it can be concluded that industrial plasters tend to break through the support/plaster interface, and do not feel any significant degradation in the surface of the finishing layer. Traditional renders are more vulnerable to surface disintegration, either in simple plasters or in double plasters. In comparison with industrial plasters, they are generally more likely to form efflorescence.

As for the behavior of the salts, the traditional double layer plasters are presented as transport plasters. In the case of simple plasters, these have a hybrid behavior since they exhibit transport behavior and, once the break occurs in the thickness of the regularization layer, they also exhibit a pattern of salt accumulation. Simple

industrial plasters are presented as blocking plasters, since the breakage has always occurred through the support/plaster interface, on the support side. The double layer industrial plasters exhibit a behavior close to the storage behavior, not being clear in the case of plaster R2+A1, since adhesion problems may have caused a capillary cut located at the support/plaster interface, changing the conditions of the test.

4 CONCLUSIONS

The present work was focused on the study of the crystallization of salts in two-layer plasters applied on a stone masonry support, in order to understand the effect of the finishing layer, the influence of the porosity characteristics of the mortars on the durability of the plasters in this form of degradation. The study also includes the comparison of renderings consisting of traditional mortars and industrial mortars.

Firstly, the study carried out shows that the finishing layer present in the double layer plaster coatings has a beneficial effect on the durability of the same, compared to the single layer plaster coat. The finishing layer is primarily responsible for a slower drying of the plaster.

The double layer plasters present greater potential to undergo surface degradation at the level of the topcoat layer by the action of the crystallization of salts when comparing to the simple plasters. However, the double layer plasters present better results when it comes to structural integrity. Thus, it is concluded that the finishing layer acts as a sacrificial layer, protecting the undercoat layer and the support.

Comparing the performance of traditional and industrial plasters against structural and surface integrity, it can be concluded that industrial plasters tend to break through the support / plaster interface, and do not present significant degradation in the surface of the topcoat layer. Traditional renders are more vulnerable to surface disintegration, both in simple plasters and in double layer plasters. In comparison with industrial plasters, they are generally more likely to form efflorescence.

As for the behavior of the salts, the traditional double layer plasters are presented as transport plasters. In the case of simple plasters, these have a mixed behavior since they exhibit transport behavior and, once the break occurs in the thickness of the undercoat layer, they also exhibit a pattern of salt accumulation. Simple industrial plasters are presented as blocking plasters, since the breakage has always occurred through the support / plaster interface, on the support side. The double layer industrial plasters exhibit a behavior similar to the storage behavior, not being clear in the case of plaster R2 + A1, since adhesion problems may have caused a capillary cut located at the support / plaster interface, changing the conditions of the test.

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